TACOMA SMELTER PLUME SITE

PIERCE COUNTY CHILD USE AREA STUDY

July, 2004

Prepared for:

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By:

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ENVIRONMENTAL HEALTH PROGRAM
CLEAN WATER. HEALTHY ENVIRONMENT. FOR LIFE.

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EXECUTIVE SUMMARY

The Tacoma-Pierce County Health Department (TPCHD) conducted the Pierce County Child Use Area Study using funding provided through a grant from the Department of Ecology (Ecology). Ecology, TPCHD, Public Health – Seattle and King County, and the environmental consulting firm SAIC worked with consultant Greg Glass to design the study. TPCHD conducted the sampling in Pierce County. A similar study in King County was conducted by SAIC environmental consultants under contract with Ecology. The primary goals of the studies were to identify areas where soil contamination from smokestack deposits of the former ASARCO Smelter in Ruston Washington could pose a health risk to children, and to raise local awareness of arsenic and lead contamination.

Child use areas (CUA's) included elementary schools, public parks, and child care centers. The sampled CUAs were located in Tacoma, Fircrest, University Place, Lakewood, Steilacoom, Fox Island and Gig Harbor. The study zone was determined by calculating the geographic area predicted to have arsenic concentrations over 100 ppm, based on data from earlier studies. TPCHD identified a total of 194 CUAs within the study zone: 40 parks, 19 public elementary schools, 5 private elementary schools, and 130 child care facilities. Access was granted for sampling 72 properties: 22 parks, 19 public schools, and 32 child care facilities. Some of the facilities which granted access were not sampled after all because they did not have child use areas or because they were paved. Two additional sites (one child care facility and one state park) located outside of the study zone were also included at the request of the property owners. In all, TPCHD sampled 16 parks, 18 public elementary schools, and 30 child care facilities.

A total of 1211 soil samples were collected and analyzed between February 25 and July 14, 2003. Four to eight samples were collected from surface soils at distinct play areas (called 'decision units', or 'DU's in this study) within each CUA. Laboratory analyses were performed by Severn Trent Laboratory (STL) in Tacoma. Data validation was performed by EcoChem, Inc. in Seattle. Based on the data quality assessments, all results reported by STL were of acceptable analytical quality.

Sample results were evaluated for individual samples, as well as for averages of all samples in a Decision Unit. The Washington State Model Toxics Control Act (MTCA) sets cleanup levels of arsenic and lead in soil at 20 ppm and 250 ppm respectively. For the Tacoma Smelter Plume project, Ecology also established Interim Action Trigger Levels (IATL), the concentration of arsenic or lead at a property at which an interim action would be warranted. These are levels above which Ecology does not want to rely solely on the soil safety practices such as hand washing, and recommends more aggressive action to keep children from playing in the contaminated soil. Interim Action Trigger Levels are set at a concentration for the average for a decision unit, and also at a concentration for one individual sample within a decision unit, as shown in the table below:

	Arsenic		**Lead**	
	Average DU	Individual	Average DU	Individual
Child Care/School	100 ppm	200 ppm	700 ppm	1400 ppm
Parks/Camps	200 ppm	400 ppm	1000 ppm	2000 ppm

Arsenic Results

Thirty eight child use properties had at least one individual sample with arsenic concentrations above the MTCA cleanup level of 20 ppm. A total of 269 individual samples contained arsenic above the MTCA cleanup level. At twenty properties, one or more decision units contained average arsenic above the MTCA cleanup level. One school had decision units with average arsenic concentrations above the Interim Action Trigger Level of 100 ppm. That school, along with one child care facility, also had individual samples above the IATL of 200 ppm for individual samples.

The following properties contained at least one decision unit with average arsenic above the MTCA level of 20 ppm.. The school with average arsenic above the IATL is highlighted in bold.

Child care facilities	**Average As (ppm)**
108	31.6
112	96.18*
116	23.25
118	30.50
121	21.04
128	36.0
137	23.5
139	38.7
144	38.6
146	28.39
168	31.95
173	47.4
Schools	
307 – Pt. Defiance	**114.2***
308 – Downing	26.9
315 – Wainwright	63.17
317 – Whittier	26.11
Parks	
436 - Curran Park (University Place)	46.04
497 - Colgate Park (University Place	45.47
442 - Sunset Terrace Park (University Place)	25.04
433 - Masko Park (Fircrest)	34.66

*Individual samples on this site exceeded the IATL of 200 ppm for individual samples

Lead Results

Eight properties had at least one individual sample with lead concentrations above the MTCA cleanup level of 250 ppm, with a total of 11 samples containing lead above the level. No properties had decision units with average lead above the MTCA cleanup level. Also, no child use areas had average lead levels or individual samples above the IATL.

At the time of sampling, TPCHD field staff discussed project objectives with property owners and operators and presented literature listing “Healthy Actions”, steps people can take to reduce their exposure to arsenic and lead in the soil. These steps were reiterated in letters sent to property owners along with the results, and in meetings arranged between property owners and TPCHD staff.

1 INTRODUCTION

The former ASARCO copper smelter operated in Ruston, Washington (a small municipality northwest of downtown Tacoma, Washington) for almost 100 years before closing permanently in 1986. Concerns over the health effects of soil contamination from smelter emissions of arsenic and other pollutants led to numerous studies starting in the early 1970s, resulting in designation of the smelter site and surrounding area as a federal Superfund Cleanup Site in the early 1980's. More recent studies have characterized the extent and pattern of contamination surrounding the old smelter outside of the Superfund boundary. These studies concluded that the pollutants from the former smokestack have been deposited onto soils over a wide area of King and Pierce Counties and correlate with distance and wind direction from the smelter. Based on these findings, the Washington State Department of Ecology (Ecology) and the Tacoma-Pierce County Health Department (TPCHD) decided it would be prudent to evaluate Child Use Areas (CUAs) in Tacoma and western Pierce County to address concerns about possible exposures in areas where small children might come into frequent contact with soils.

1.1 CUA Purpose and Objectives

The Tacoma-Pierce County Health Department (TPCHD) collected and analyzed soil samples from 64 child use areas (CUAs) on mainland Pierce County and Gig Harbor between February and July of 2003. The primary objective for sampling soils at CUAs was to identify locations where smelter-related contamination poses the greatest exposure risks to young children. Young children (up to the age of 6) are considered to be at higher risk of exposure because they come into frequent contact with soil, exhibit more mouthing behaviors, and are more sensitive to contaminants. The study also continues TPCHD's outreach and education efforts to raise awareness of arsenic contamination in Pierce County.

The depth profiles of soil contamination where soils have been disturbed by development activities can be complex, with contamination extending well below depths affected in undisturbed soils. Sampling at child use areas was not intended to fully characterize soil contamination at each property, or to necessarily identify the maximum concentrations occurring at any depth. The emphasis on potential soil exposures under current conditions meant limiting sampling to near-surface soils where soil contact is most likely to occur. For this reason, this study is a "health screening level" study rather than a MTCA site characterization study or remedial investigation.

1.2 Organization and Personnel

The design of the study components (selecting the child use areas to be sampled, sample locations, sample depths, and analyses performed) was a collaborative effort between Washington State Department of Ecology (Ecology), TPCHD, Public Health-Seattle & King County, the consulting firm SAIC, and was led by Gregory L. Glass, an independent consultant. This group is referred to as the Study Design Group (Table 1). SAIC was contracted by Ecology to carry out the child use area sampling in King County.

Table 1: Sample Design Group Participants

Agency/Company	Name	Role
Washington Department of Ecology	Marian Abbett	Project Coordinator
	Joyce Mercuri	Site Manager, Pierce County CUA Study
	Guy Barrett	Site Manager, King County CUA Study
	Norm Peck	Ecology Northwest Region Representative
Pierce County Health Department	Glenn Rollins	TPCHD Project Lead
	Jennifer Olson	TPCHD Field Sampler
	Lindsay Spencer	TPCHD Field Sampler
Public Health – Seattle and King County	Nicole Fus/Charles Wu	Team Lead, Tacoma Smelter Plume Project
	Gary Irvine	Environmental Health Services Supervisor
SAIC	Doug Pearman	Contractor to Ecology for King County CUA sampling
Gregory Glass Environmental Consulting	Greg Glass	Study Design Consultant

2 HISTORIC STUDIES

Previous studies have characterized smelter emissions and documented environmental contamination in areas surrounding the former Tacoma Smelter. Historic studies have been compiled and placed in Tacoma Smelter Plume Site project files at the Ecology and local health departments. References for historic studies are available in previous study design documents (c.f. Glass 1999, 2000, 2001, 2002). Compact discs with copies of older historical studies are also available at the Ecology site files. The geographic areas sampled, the types of land uses at sampled properties, the sampling and analysis protocols, and the intensity of sampling varied greatly among studies.

2.1 Studies through smelter closure

The early studies sampled a variety of environmental media to document contamination in areas surrounding the Tacoma Smelter. Sampled media included airborne particulates, precipitation, soils, house dusts, vegetation, sediments, surface water, reservoir sludges, bees, cows, and fish tissue, as well as human urinary and blood samples. Soil sampling included forested properties, roadside soils, residential areas, vacant lots, playfields, and gardens. With the exception of extensive garden soil testing and regional-scale precipitation chemistry monitoring, the early studies were generally small in scale and limited in geographic coverage. Sampling and analytical protocols varied significantly among studies.

Taking advantage of the announced closure date for smelter operations, several studies performed comparative pre- and post-closure sampling at the time of smelter shutdown. A comprehensive multimedia study was also performed at that time by a University of Washington research team to investigate the environmental pathway(s) by which community residents, especially young children, were being exposed to arsenic (Polissar et al. 1987). That Arsenic Exposure Pathways Study, while compiling new sampling information for multiple census tracts on Vashon-Maury Island, Ruston, and North Tacoma, was not designed to define the geographic nature and extent of soil contamination.

2.2 Superfund studies

Between 1987 and 1992, Ecology and USEPA performed a series of studies to define the nature and extent of residual soil contamination in areas near the former smelter (Ruston and North Tacoma, within a distance of approximately one mile). Those studies included a dense grid of sampling locations within the restricted study area. Selected soil samples were also analyzed for an extended list of elements, documenting correlations among elements related to smelter operations and emissions. Once cleanup actions at residential properties began under a Superfund Record of Decision, property-by-property sampling results provided an extremely detailed data set for soil contamination patterns and magnitudes. Cleanup actions at Ruston/North Tacoma properties are continuing under EPA's Superfund program.

2.3 Tacoma Smelter Plume Studies

Ecology, in cooperation with local health departments, is investigating widespread contamination from smelter emissions extending beyond the designated EPA Superfund site. Discovery of elevated arsenic and lead levels in University Place in 1997, and at a gravel pit on Maury Island in 1999, prompted Ecology to begin regional soil studies referred to as Tacoma Smelter Plume (TSP) studies. Five soils investigations have been performed under the TSP program as of 2004. Samples were analyzed for arsenic and lead, and some for additional tracer elements. Those studies are:

1) <u>Vashon-Maury Island Initial Footprint Study (1999)</u>. This study collected and analyzed samples from 177 <u>forested</u> locations covering all of Vashon-Maury Island and near-shore areas on the King County Mainland east of Vashon-Maury Island.

2) <u>Vashon-Maury Island Child Use Areas Study (2000)</u>. A total of 34 child use areas (beaches, parks, camps, schools, preschools, and child care centers) and some nearby forested sites were sampled.

3) <u>King County Mainland Initial Footprint Study (2002)</u>. Samples were collected from 59 relatively undisturbed forested sites over an area approaching 200 square miles.

4) <u>Pierce County Initial Footprint Study (2002)</u>. This study covered approximately 200 locations, over an area <u>approaching</u> 200 square miles (those portions of Pierce County west and north of I-5), to evaluate the regional-scale pattern of smelter-related soil

contamination in western Pierce County. Sampling locations include both forested and residential properties.

5) King County Mainland Child Use Area Study (2003). The parallel study to this Pierce County Child Use Area Study report was completed in King County by SAIC. A total of 97 child use areas were sampled.

An additional study is currently underway (Summer, 2004) to evaluate the wider extent of the contamination "footprint" in Pierce, King, Thurston, and Kitsap Counties.

TSP studies differ from previous investigations in that they have an expanded, regional-scale area of coverage, a systematic approach to selecting the land use types being sampled, consistent sampling and analysis protocols for regional sampling coverage, and a large number of samples, with a comparatively high sampling intensity. The results of TSP investigations are generally consistent with information from the previous studies, but they increase the knowledge of the magnitude and extent of regional soil contamination. Statistical and spatial evaluations of the data support the following conclusions:

- Results demonstrate a broad range of contaminant concentrations, from less than 1 ppm to substantially elevated levels.
- Contaminant levels are affected by history of property development and soil disturbance
- There is a large-scale spatial pattern of contamination. The regional-scale pattern of environmental contamination shows a distance/direction versus concentration relationship consistent with airborne smelter emissions and local wind rose patterns.
- The study area exhibits small-scale variability. Even within a distance as small as 50 feet, concentrations can vary several-fold.
- Levels of arsenic, lead, cadmium and other heavy metals demonstrate a high degree of correlation.

3 CHILD USE AREA STUDY DESIGN

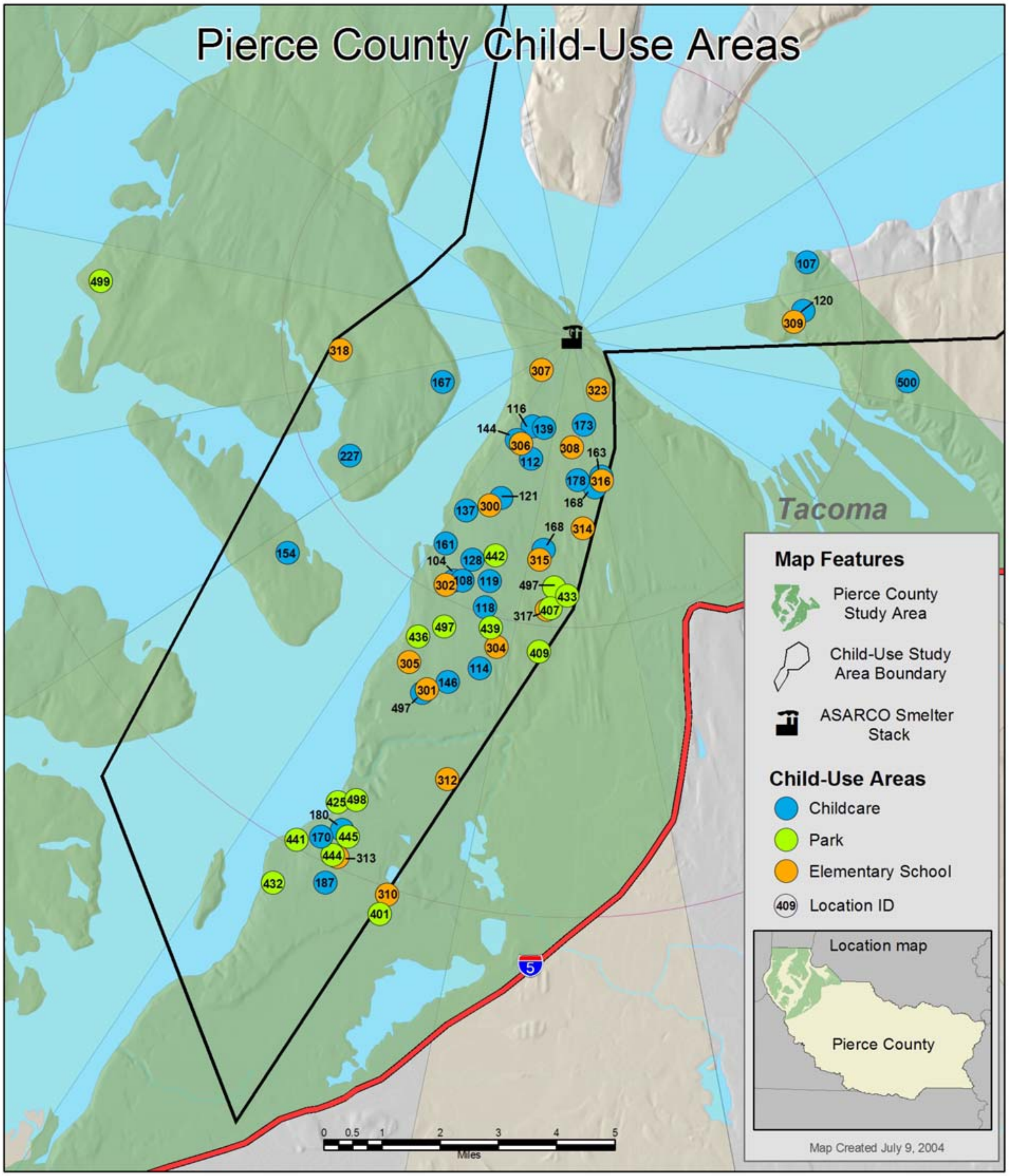
3.1 CUA Boundary

Based on sample results from relatively undisturbed properties (Glass 2004) which likely represent the upper limit of contaminant concentrations, and on prevailing wind directions from the smelter site, a boundary line was calculated to include all those sites where arsenic concentrations might exceed 100 ppm (the lowest interim action concentration identified by Ecology). A map of the study area and the sites sampled is shown on Figure 1. The general methodology for developing the boundary is detailed in Attachment A.

3.2 Identification of child use areas

Child use areas include any properties where young children are likely to be present with some frequency, and where their activities will put them in contact with potentially contaminated soils. Areas sampled for this study include elementary schools, preschools, child care facilities, parks, and playfields. Based on the results of sampling beaches on Vashon-Maury Island (PHSKC and Glass 2001), where arsenic and lead concentrations were uniformly low, beaches were excluded from this study.

Figure 1. Child Use Area Boundary And Facilities Sampled



TPCHD identified schools and parks from database lists provided through the Pierce County GIS system. A current list of licensed child care facilities in Pierce County was obtained from the Washington State Department of Social and Health Services (DSHS) and the Yellow Pages. Key contact people at local governments and neighborhood groups were also asked about other child use areas in their communities that were not listed in existing databases. TPCHD identified a total of 194 child use properties as potential sampling sites within the study area. The properties included 19 public and 5 private elementary schools, 40 parks, and 130 child care facilities. One child care facility and one state park outside of the project study zone were also included in the study at the request of the property owners.

3.2.1 Prioritization scheme

A system was developed by the study design team to prioritize sampling of the CUAs most likely to have high concentrations of lead and arsenic. Information on four factors was compiled for each CUA to derive a numerical score for establishing sampling priorities: distance and direction from the smelter site, number of young children using the facility, frequency of use, and the development history of the property. Data on facility development history and the number of children using the site were gathered from access agreements and interviews with owners and operators as well as the DSHS database. Properties that had no information about the year of last development were given a default year of 1940 for the City of Tacoma, 1970 on the Gig Harbor Peninsula and Fox Island, and 1960 for all other areas.

The individual scores on these four factors were combined to calculate a single overall score for each candidate child use area (see Attachment B for details). The child use areas were then prioritized by these scores, with higher scores indicating a higher priority for sampling. Priority was given to CUAs that were closer to the smelter site, that were downwind, which had larger numbers of young children using the facility, and that had not had major development or redevelopment since smelter closure. This system was developed to make the best use of limited agency resources, which would not permit sampling of every site; however, because so few child care facilities returned access agreements, all sites which allowed access could be sampled.

3.2.2 Access agreements

TPCHD made personal contact with the school districts to gain access to public schools and contacted local governments for permission to sample at parks. The personal contacts were followed up with a written access agreement form. Access from private schools and private child care operators was requested by mailing the written access agreement with a cover letter explaining the project to the property owners of child use areas selected for sampling (Attachment C). The access agreement addressed the legality of entering and sampling property and inquired about the number and age of children using the facility or property, property history, and specific areas used by the children. The access agreement also provided a check box where property owners could request a copy of the results of the samples collected from their property. No sampling was performed without a completed access agreement.

In all, TPCHD received permission to sample all 19 public elementary schools, 33 of 131 child care facilities (including one outside of the study boundary), and 22 of 41 parks (including one state park, Kopachuck, which was outside of the study boundary). Some of the sites for which we gained access were not sampled because they did not contain child use areas or exposed soils. A complete discussion of sites sampled and not sampled is included in Section 4.

3.3 Sampling strategy

3.3.1 Exclusion areas

Exclusion criteria were established to concentrate on areas most likely to contain contamination from the smelter and to avoid confounding results from non-smelter sources of contamination. Excluded areas include:

- Areas within ten feet from roads and twenty feet from railways
- Wetlands
- Steep slopes
- Flood plains
- Lakes
- Shorelines
- Areas with restricted access
- Areas with substantial soil disturbance
- Areas that have already had extensive sampling
- Inaccessible soils, such as those beneath buildings, paved driveways or patios
- Areas with cover one foot deep or more, such as gravel, wood chips or sand
- Areas with a barrier, such as a rubber mat or a liner covered with gravel, wood chips, or other non-soil material
- Three feet from possible treated wood structures such as play sets and fences
- Five feet from painted structures that may have lead-based paints

The Ruston/North Tacoma Superfund site was also excluded from the study. However, Point Defiance Elementary School was included in the study, even though part of the property lies within the Superfund site.

3.3.2 Decision units, borings, and depths

Child use properties were subdivided into multiple areas that reflected various activities, land uses, property histories, or other factors. These areas were called "decision units" (DU), since the decisions on appropriate response actions varied from one portion of the property to another. Small child use areas such as child cares usually contained a single decision unit. Elementary schools often contained two or three. The maximum number of decision units at any site was three.

Decision units were defined at the selected child use areas by the field sampling teams, based on observations and discussions with property owners. The set of defined decision units did not have to provide complete coverage of the entire property. For example, areas that were not used by children, play areas that already had a deep cover layer (such as sand or wood chips) that minimized contact with potentially contaminated soils, or landscaped areas, were not sampled.

Samples were collected from 4-10 borings at each decision unit. Field samplers selected boring locations at the time of sampling. Samples were collected from two depth intervals in each boring, 0-2 inches and 2-6 inches. The "zero" depth from which depth measurements were taken was defined as the bottom of the root mass for grass cover, just below other types of cover (e.g., wood chips), or just below the duff layer, if one existed. These two depth intervals provide information to characterize near-surface soils in areas where children may be exposed to them. The depth intervals are consistent with the near-surface intervals used throughout the set of Tacoma Smelter Plume investigations.

All samples collected and analyzed at child use areas represent discrete samples, collected from a single depth interval from a single boring. Soils from multiple borings, or multiple depth intervals within a boring, were not composited for lab analyses. Discrete samples provide the most detailed information on soil contamination in a decision unit; however, the sampling design was not intended to provide complete characterization of soil contamination at a DU.

3.3.3 Sample numbering scheme

The sample numbering scheme was designed to incorporate all the essential information about the property, DU, and the specific boring.
An example of a sample number is: 124-3-07-1-6, where fields are:

Property I.D. # - Decision Unit # - Boring # - Depth - Type of Sample

- The **property identification number** is a three-digit number that uniquely identifies the property. Properties 101-299 are child cares; properties 300-399 are schools; properties 400-499 are parks; and properties 500-599 do not fall in to one of the other categories. The properties are numbered in descending rank (i.e., the highest ranked child care is number 101, the highest ranked school is 300, etc).

- The **decision unit number** represents the specific decision unit on the property that was sampled.

- The **boring number** represents the boring in the sequence it was collected within one DU.

- The **depth number** represents whether the sample was taken from 0-2” or 2-6”.
  0-2” depth: **1**
  2-6” depth: **2**

- The **type of sample** category (see Quality control, below) represents the specific sample type as follows:
  - Regular soil sample: **4**
  - Duplicate sample: **5**
  - Rinsate sample: **6**

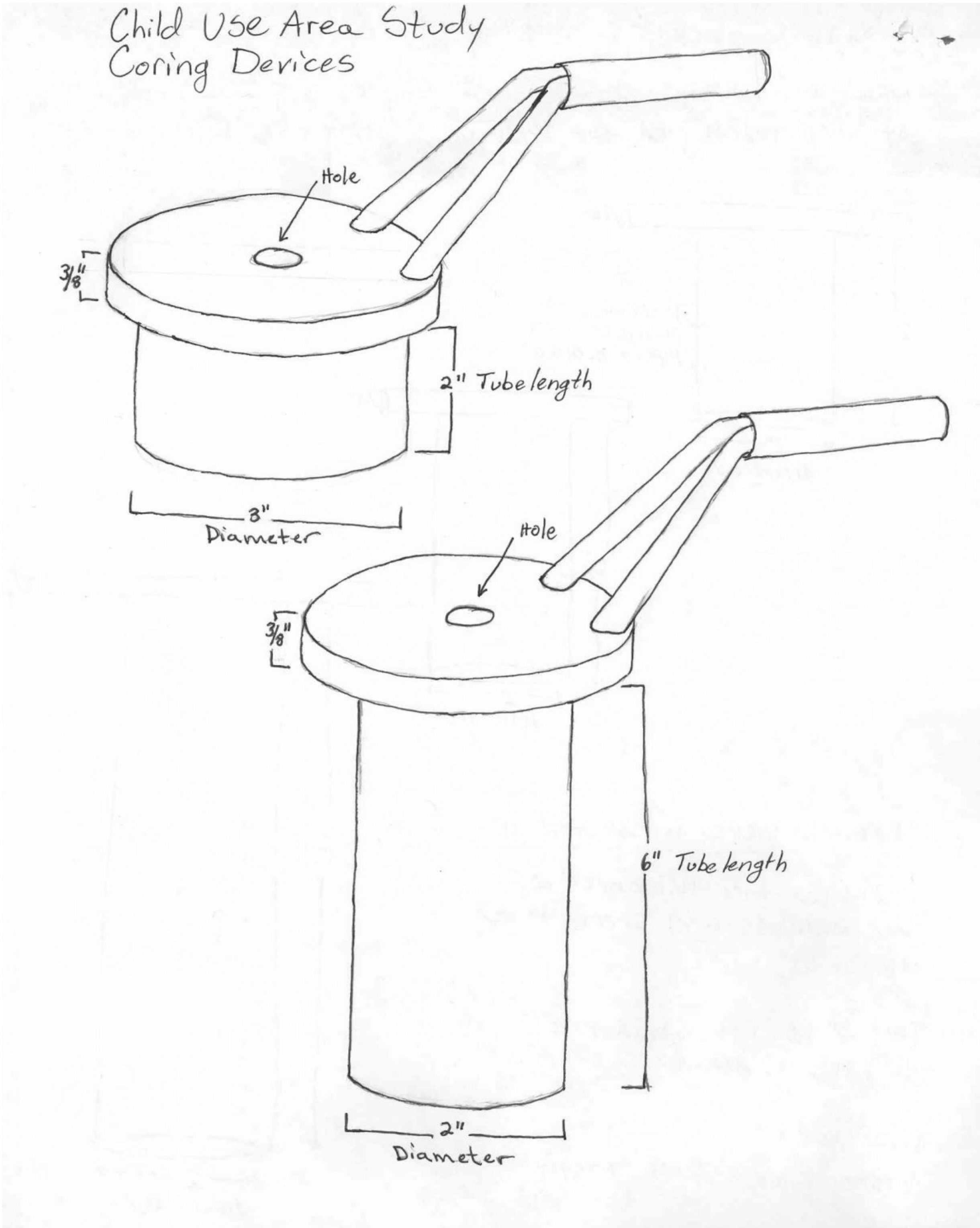
3.3.4 Equipment

The following equipment was used when collecting samples in the field:

- Backpack
- 2 stainless steel coring devices, lengths 2” and 6”
- Four pound mallet
- Latex gloves
- Earplugs
- Stainless steel bowls, spoons and trowel
- Crowbar
- Aluminum foil
- Rite-in-the-Rain field data sheets and pens
- Orthographic photos of the property
- Labels and stickers for the sample jars
- Gardening topsoil
- Liqui-Nox® detergent and deionized water
- Bottlebrushes
- 8 oz. Sampling jars (provided by STL)
- Pre-preserved (HNO_3) sample rinsate bottles (provided by lab)
- 2 gallon water sprayer
- De-ionized water (provided by STL)
- Kneeling pads
- Garbage bags
- Cooler and ice packs for sample storage in the field

The coring devices are 2- and 6-inch long stainless steel tubes with a diameter of 3” and 2” respectively. They are topped with 3/8” steel plates and handles (Figure 2). The devices were designed by Ecology and modified for this project. They were made at Zeigler’s Welding in Olympia, Washington.

Figure 2. Coring Devices Used For Collecting Soil



3.3.5 Field protocol

A two-person team performed the soil sampling. Property owners were notified prior to sampling to arrange a time and date. While sampling, the residents/owners of the property were able to observe the sampling procedure outside the 10-foot radius of the sampling location. Below is the description of sample protocol while samplers are on site.

a. Samplers donned latex gloves prior to beginning work.
b. Any fallen leaves, pine needles, or other non-soil materials on the ground were removed (this does not include grass).
c. The 2" long coring device was driven into the ground using a four-pound mallet.
d. The coring device was removed from the ground, using a crowbar if necessary.
e. The soil was transferred from the pipe to aluminum foil or a stainless steel bowl by tapping lightly on the outside of the pipe with the mallet. The sample was kept out of the wind to prevent fine soil from blowing away. If the soil did not remain in the coring device when it was removed from the ground, the field staff dug the sample out using a clean stainless steel spoon.
f. If the coring device could not be driven into the ground due to an obstruction such as a large rock or root, the boring was either abandoned and a second adjacent hole created, or the obstruction was removed with the spoon or crowbar and sampling resumed. Any soil samples that were collected in an abandoned boring were discarded and the hole refilled.
g. Any tufts of grass and roots were removed from the sample. The soils were shaken from the roots onto the foil. Any large rocks or organic matter, such as sticks or roots, were removed (clay and soil particles were left in place, which the lab processed when sieving.) The soil was homogenized before being placed the sample jar.
h. The soil sample was transferred into sterile glass jars provided by STL Seattle Laboratory, using the stainless steel spoons. The jars were labeled with: the date and time, sampler name or initials, sample number and location, and a bright sticker to easily identify the sample as a TPCHD sample.
i. The 6" coring device was placed into the same hole to obtain the 2-6" sample, which was processed as described above.
j. Sample core equipment, spoons, and bowls were decontaminated by scrubbing with a brush and diluted Liqui-Nox® detergent, and rinsing with deionized water.
k. The site was returned to as close to the original conditions as possible, backfilling the borings with clean topsoil or sand and replacing the grass plug.
l. All information was collected and recorded on field data sheets, orthophotos, sample label, and chain of custody form.
m. Samples were delivered to STL Seattle where they were placed in a locked refrigerator and maintained at $4^{o}C$ until analyzed.

3.4 Quality control

A Quality Assurance Project Plan for the Child Use Area Project covering both Pierce and King Counties was developed by Ecology contractor SAIC (SAIC, 2002). A separate Field Sampling

Plan for the Child Use Area Project in Pierce County was developed by TPCHD (TPCHD, November, 2002).

3.4.1 Field duplicates

Field precision was assessed through the analysis of duplicate field samples collected from a particular sampling point. Approximately 5% of the total samples were collected as duplicates, spatially located throughout the study area. Duplicates were collected for the 0-2" and 2-6" depths from the same boring. A single sample was placed on a sheet of aluminum foil, any large rocks or sticks removed, homogenized using a stainless steel spoon, split in half, and analyzed as two separate samples. The location of field duplicate samples was not pre-selected because they were a test of field variability and sample collection competence. The locations were positioned throughout the study area and mapped to show where the duplicates were collected. All field duplicate samples fell well within the 50% relative percent difference acceptance limits specified in the QAPP.

3.4.2 Field rinsates

The equipment rinsates were obtained by rinsing the sampling equipment with deionized water after it was decontaminated, and collecting the water in an 8-oz plastic sample container provided by the lab. All containers used for the rinsate samples contained a small amount (~2 ml) of HNO_3 as a preservative. The container was labeled with the date and sample number using the sample numbering scheme described above, placed in a cooler with "blue ice" ice packs, and transported to STL Seattle as a rinsate sample. The sample number and type were noted on the field data sheets.

Equipment rinsate samples were collected for approximately 2.5% of the total samples, or every fortieth boring. The potential for cross contamination of samples from equipment is very low with proper washing. Rinsate results were not expected to be highly important to successful soil sample results, thus the low frequency of rinsates. The location of rinsate samples was not pre-selected because they are a test of field and sample collection competence. The locations were dispersed throughout the study area. Each rinsate spot was mapped to show which properties had rinsates collected. The rinsate samples were collected for each sampling depth in the boring. All rinsate sample results were below detection levels.

3.4.3 Decontamination and waste handling

To prevent the cross-contamination of samples, sampling devices were washed after each sample was collected to remove any adhering soil. The sampling devices were cleaned using Liqui-Nox® detergent, deionized water and a bottlebrush. Liqui-Nox® detergent is made by Alconox, Inc. and does not contain any phosphates that could affect sample results. The detergent was diluted, with one liter of water per10 ml Liqui-Nox®. The wastewater generated from washing and rinsing tools was discarded on the site.

3.4.4 Sample shipping and chain of custody

Samples were placed in a cooler with "blue ice" packs and kept in the field until transferred to STL Seattle. Samples were generally transported to STL Seattle the day they were collected, or sometimes held overnight at TPCHD in a secure refrigerated location. The Chain-of-Custody form was included in each sample shipment (Attachment D). The forms were printed from a STL Seattle template. The chain of custody forms indicate the date the samples were collected and the date they were delivered to STL Seattle. STL Seattle was responsible for filling out the chain of custodies and shipping all soil samples for further analysis.

3.5 Sample Analysis

3.5.1 Analytical methods

Prior to digestion, the entire soil sample was removed from its container, sieved through a 2mm sieve, then homogenized. This procedure is consistent with MTCA protocols [WAC 173-340-740(7)(d)]. The portion of the sieved homogenized material that was not needed for the primary analysis was returned to the original container. The samples were then prepared using a microwave digestion technique (USEPA SW 846 Method 3051A). Total arsenic and lead in the soil samples was analyzed by ICP-mass spectrometry (ICP-MS; USEPA method 6020). The reporting limits (RL) for this project are the practical quantitation limits (PQL). The PQL for the ICP-MS method is 1.0 mg/kg for arsenic and 0.5 mg/kg for lead. The laboratory method detection limits (MDL) for ICP-MS are 0.1537 mg/Kg for arsenic and 0.0232 mg/Kg for lead. Percent moisture was determined for each sample and sample results reported on a dry-weight basis.

The water samples from the field equipment rinsates were also analyzed for arsenic and lead. The samples were preserved in jars containing 2ml of nitric acid. The water was digested using Method 3015A and analyzed using ICP-MS.

3.5.2 Laboratory QA/QC

The laboratory was required to complete several QC elements; some were required by the EPA analytical method, others were project-imposed, in order for the data to be considered valid and accurate. These elements are as follows:

- Chain-of-custody and technical holding times: the sample chain-of-custody must show that, once the samples were received by the laboratory, they were under constant custody and control of the laboratory. The EPA analytical method requires that samples be digested and analyzed within 180 days of sample collection.
- Initial and continuing calibration verification
- Blanks (instrument, method, and field)
- Standard reference materials
- Matrix spike and matrix spike duplicate samples
- Laboratory duplicate samples
- ICP interference check samples

- ICP serial dilution

The frequency, acceptance criteria, and resulting laboratory action for each of these QC elements are explained in the quality assurance project plan (QAPP; SAIC 2002).

One hundred percent of the data were validated by EcoChem. The data were reviewed using guidance and quality control criteria documented in the analytical method, the QAPP (SAIC 2002) and National Functional Guidelines for Inorganic Data Review (USEPA 1994). Ten percent of the data packages received a full data review (commonly called a Level IV validation) and the rest received a compliance screening evaluation (commonly called Level III). Technical validation involves comparison of QC standards and instrument performance results to required control limits. In addition, the laboratory electronic data deliverable (EDD) was loaded into the data quality screening tool (EcoChem DQST). The following QC elements were reviewed for data packages undergoing summary validation:

- Analytical holding times (from summary forms).
- Chain of custody and sample handling
- Preparation Blank contamination (from summary forms)
- Initial and continuing calibration verification (from summary forms).
- Continuing calibration blanks (CCB) (from summary forms and raw data).
- Interference check samples results (from summary forms and raw data).
- Internal standards, ICP/MS only (from summary forms).
- Instrument tuning standards, ICP/MS only (from summary forms).
- Analytical accuracy (matrix spike compounds and standard reference materials [SRM]), expressed as percent recovery (%R; from summary forms).
- Analytical and field precision (comparison of duplicate sample results) expressed as relative percent difference (RPD; from summary forms).
- Reported detection limits (from sample result summaries).

Full validation included a review of all the items listed above for summary validation, plus the following QC elements:

- Compound identification (from raw data).
- Compound quantitation, transcription and calculation checks (from raw data).
- Transcription and calculation checks performed at a frequency of 10%. If an error was noted, 100% of the calculations and transcriptions for that data set were verified.

Full validation was performed on the initial data package and on approximately 10% of randomly selected data packages produced throughout the project. No significant deviations from required protocols and QC criteria were noticed; the remaining data (approximately 90%) received a summary validation.

No sample results were rejected during validation. No sample results were changed from detects or estimated detects to non-detects during the validation process.

4 RESULTS

As described in section 3.2.2, TPCHD received permission to sample all of the 19 public elementary schools, 33 of 131 child care facilities (including one outside of the study boundary), and 22 of 41 parks (including one state park, Kopachuck, which was outside of the study boundary). A final summary of properties actually sampled is shown on Table 2 and includes: 18 public elementary schools, 30 child care facilities, and 16 parks. An explanation of sites not sampled is shown below:

- Five private elementary schools did not return the access agreements.
- Fourteen facilities operated by Metro Parks Tacoma were not sampled because Metro Parks, Ecology, and TPCHD did not agree on conditions requested by Metro Parks for an access agreement to conduct the sampling.
- Five additional parks did not return access agreements: Chambers Creek Park (Department of Natural Resources), Fox Island Playfield, Dash Point and Fort Steilacoom Parks (Washington State Parks), and the Brown's Point Lighthouse Park (U.S. Lighthouse).
- Six of the parks that provided access were not sampled because they did not contain child use areas or exposed soils (for example, wetland or nature parks, paved areas). Those parks were: Emerson Park (Fircrest), Saltar and Farrell Marsh Parks (Steilacoom), City Park and Adriana Hess Park in University Place, and Alice Peers Park in Fircrest.
- Three of the child care facilities were not sampled because they did not have soils to sample – for example their play areas contained wood chips or gravel.
- Washington-Hoyt Elementary School in the Tacoma School District had paved play areas so was also not sampled.

Table 2. Child Use Facilities Sampled

SCHOOLS	
<u>Clover Park School District</u>	**<u>Steilacoom School District</u>**
Lake Louise Elementary School	Cherrydale Elementary School
Oakbrook Elementary School	
	<u>Tacoma School District #10</u>
<u>Peninsula School District</u>	Brown’s Point Elementary School
Harbor Heights Elementary School	DeLong Elementary School
	Downing Elementary School
<u>University Place School District</u>	Geiger Elementary School
Chambers Primary School	Jefferson Elementary School
Evergreen Primary School	Point Defiance Elementary School
Sunset Primary School	Skyline Elementary School
University Place Primary School	Sherman Elementary School
	Wainwright Elementary School
	Whittier Elementary School
PARKS	
<u>Fircrest</u>	**<u>University Place</u>**
Fircrest Park	Curran Apple Orchard
Tot Lot	Homestead Park
Whittier Park	Sunset Terrace Park
Alameda Park	Curtis/Colgate Park
Masko Park	
	<u>Lakewood</u>
<u>Steilacoom</u>	Washington Park
Sunnyside Park	
Cormorant Park	**<u>Washington State</u>**
Webber Court Community Park	Kopachuck State Park
Cherrydale Park	
Manitoba Park	
CHILD CARE CENTERS (# of facilities in each municipality)	
Fircrest (1)	Steilacoom (2)
Fox Island (1)	Tacoma (16) (NE Tacoma -1)
Gig Harbor (2)	University Place (7)

4.1 Comparisons to MTCA cleanup levels

The Model Toxics Control Act (MTCA) is the Washington state law governing cleanup of contaminated soil, water, and air in Washington. MTCA cleanup levels are:

- 20 parts per million for arsenic
- 250 parts per million for lead

4.1.1 Individual samples

A total of 1211 samples were collected and analyzed during this study. Refer to Attachment E for a complete list of results for each property. Contaminant levels of individual samples exhibited a wide variation, ranging from 0.94 – 691 ppm for arsenic and 1.32 – 1040 ppm for lead. Two hundred and sixty nine individual samples (22%) contained arsenic above the MTCA cleanup level. Eleven individual samples (less than 1%) contained lead above he MTCA cleanup level.

Of the 64 properties sampled, 38 had at least one individual arsenic result above MTCA limits, including 20 child cares, 10 schools, and 8 parks (Table 3). Seven child use properties contained at least one individual lead result above MTCA limits, including 3 child cares, 2 schools, and 2 parks. One child care (#112) had particularly high arsenic and lead levels in an individual sample: 429 ppm arsenic and 502 ppm lead. Point Defiance Elementary also stood out, with individual samples containing 691 ppm arsenic and 1040 ppm lead.

4.1.2 Decision Unit Averages

Average lead and arsenic values were calculated from the 4-10 individual samples obtained at decision units at each property. Twenty facilities (31%) contained decision units in which average arsenic contamination exceeded 20 ppm in one or both depth profiles: 12 child cares, 4 schools, and 4 parks (Table 3). Again, child care #112 and Point Defiance Elementary had notably high averages. At Point Defiance, all three DUs had average arsenic levels over MTCA. Other public schools with elevated average average arsenic contaminant levels were Downing, Wainwright, and Whittier Elementary – all within the Tacoma School District. No child use area had average lead levels over the MTCA cleanup level. The highest average concentrations for a DU were 114.42 for arsenic and 170.30 for lead, both at Point Defiance Elementary School.

4.2 Comparisons to Interim Action Trigger Levels

Ecology also developed "interim action trigger levels" (IATL), contaminant levels above which Ecology does not want to rely solely on soil safety guidelines such as hand washing, and recommends more aggressive action to keep children from playing in the contaminated soil. Ecology refers to these as interim actions. IATL are based on risk assessment methods, a detailed description of which can be found at on the Department of Ecology Web Site at: http://www.ecy.wa.gov/programs/tcp/sites/tacoma_smelter/ts_q_and_a.pdf

The Interim Action Trigger Levels are:

	Arsenic		Lead	
	Average DU	Individual	Average DU	Individual
Child Care/School	100 ppm	200 ppm	700 ppm	1400 ppm
Parks/Camps	200 ppm	400 ppm	1000 ppm	2000 ppm

For child use areas with averages above these levels, Ecology plans to work with the property owner to determine ways to provide clean play areas for children.

4.2.1. Individual samples

Only two properties had individual samples that were above individual IATL level: child care #112, which had three samples with 257, 331, and 429 ppm arsenic; and Point Defiance Elementary (#307), which had arsenic levels of 557 and 691ppm. There were no individual lead samples above the IATL.

4.2.2 DU averages

Only one property, #307 (Point Defiance Elementary) contained an average in a DU that exceeded the IATL. The average level of arsenic at a decision unit on this site was 114.4 ppm. The maximum individual and average was in a vacant parcel adjacent to the school grounds that is not regularly used by children, but may be developed for school use in the future. This area had some soils removed in the past as a part of the Asarco Superfund cleanup (part of the site is in the Superfund Cleanup zone). Some individual samples on the main school grounds did contain levels of arsenic which were of concern to school officials, although not above the IATL. In response, officials in the Tacoma School District capped the playground with asphalt, and the top two feet of soil from the ballfield were removed and replaced with clean fill.

Table 3. Properties With Arsenic or Lead Above MTCA and IATL Limits*

Site #	Name	Decision Unit # 1 Average above MTCA				Decision Unit # 2 Average above MTCA				Decision Unit # 3 Average above MTCA				Highest Individual Result above MTCA		Exceeds IATL (average or individual)	
		0-2”		2-6”		0-2”		2-6”		0-2”		2-6”					
		As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb
Child Care Facilities																	
107														42.1	311		
108		24.2		31.6										43.5			
112		77.1		96.2		67		28.1						429	502	*	
114														29.9			
116		20.4		23.2										40.4			
118		30.5		29.7										68.1			
120														20.9			
121				21										63.5			
128		36.0		29.3										65.0			
137				23.5										31.2			
139		38.7		36										74.6			
143														25.0			
144		21.9		38.6										60.9			
146				28.4										74.3			
161														20.6			
168		32		29.5										51.5	272		
173		43.4		47.4										60.3			
178														25.5			
222														22.3			
500														32.9			

Site #	Name	Decision Unit # 1 Average above MTCA				Decision Unit # 2 Average above MTCA				Decision Unit # 3 Average above MTCA				Highest Individual Result above MTCA		Exceeds IATL (average or individual)	
		0-2”		2-6”		0-2”		2-6”		0-2”		2-6”					
		As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb	As	Pb
<u>Schools</u>																	
301	Chambers													37.1			
315	Wainwright									63.2		33.9		142.0	382		
317	Whittier					20.4		26.1						48.3			
307	Pt. Defiance			31.2		40.3		20		91.3		114.4		691	1040	*	
308	Downing	23.6		26.9										99			
309	Brown’s Point													27			
318	Harbor Heights													37.7			
310	Lake Louise													39.7			
305	Sunset													52.8			
313	Cherrydale													72.5			
<u>Parks</u>																	
409	Alameda													28.2			
433	Masko	34.7		25.3										78	250		
436	Curran	33.5		46.04										148			
439	Homestead													46.4			
442	Sunset Terrace			25										67.1			
497	Colgate	32		45.5										93.5			
498	Manitoba													25.9	595		

* Only exceedances are shown on this table. Blank squares in the table indicate that the property did not have this decision unit or that there were not exceedances. If a property is not listed on this table, there were not exceedances of the MTCA or IATL levels at that site.

<u>Table 3, continued</u>

4.3 Additional data analysis

The intent of the Child Use Area study was to determine if any properties where small children play present any health risks due to arsenic or lead contamination in soil. With this objective in mind, soil samples were collected, analyzed and compared to MTCA Cleanup Levels and Interim Action Trigger Levels (Sections 4.1 and 4.2 above).

In the following sections, an attempt was made to find global, or region-wide, trends in the resulting data. A caution must be noted: previous Tacoma Smelter Plume studies (and supported by this study) demonstrate that soil sampling results should not generally be assumed to be representative of unsampled areas at that property or other nearby properties based on the high variability of the results. Property-specific sampling is recommended for determining the degree of soil contamination at a property or area of interest. The larger spatial patterns are most useful in establishing a range within which property-specific results are expected to occur, rather than predicting actual levels of contamination, which are strongly affected by property development histories and local variations in the deposition of airborne contaminants.
The following data evaluations assume that the data are parametric, which may not be true. The variability within the data set indicates that there are factors affecting contaminant distribution that Ecology and the Tacoma-Pierce County Health Department do not understand and cannot draw meaningful conclusions about with the data currently available. These comparisons MAY provide some preliminary clues about potential sources of variability, and/or some preliminary suggestions of trends when viewed in combination with data from previous studies. Do not rely on the results of these evaluations as the basis for any regulatory or planning decisions at any higher level than the property-specific evaluations discussed in section 4.2 above.

4.3.1 By depth

Taking the child use area data set as a whole, the distribution of arsenic and lead in the 0-2" layer was compared to the distribution in the 2-6" layer in a pairwise comparison using the Student's t-test. Total mean arsenic and lead concentrations by depth did not exhibit any statistical significance (paired t-test: $p = 0.135$ for As, $p = 0.114$ for Pb). That is - the amount of contamination appears to be the same in the 0-2" layer as it is in the 2-6" layer if the data set is looked at as a whole. Review of the data by depth for different wind directions is discussed in the next section. (See attachment G for the t-test results).

4.3.2 By wind vector

The wind rose from the smelter was divided into 16 different vectors of 22.5 degrees each, designated A through P (Figure 3). Wind vector A covered 11.25 degrees on either side of true north (348.75 to 11.25 degrees). Wind vector B included 11.25 through 33.75 degrees, and so on. Wind vectors covered in this study were D, E, H, I, J, K, L and M. Means and standard deviations of arsenic and lead concentrations for the 0-2" and 2-6" depths were calculated for samples in each wind vector to look at differences in arsenic and lead concentrations versus wind direction (Tables 4 and 5). In a number of cases, the standard deviation is higher than the mean, demonstrating the wide variation in the data. Distribution of all samples (without regard for depth) by wind vector is shown on Figures 4 and 5.

FIGURE 3: Wind Vectors and Child Use Area Boundary for Pierce and King Counties

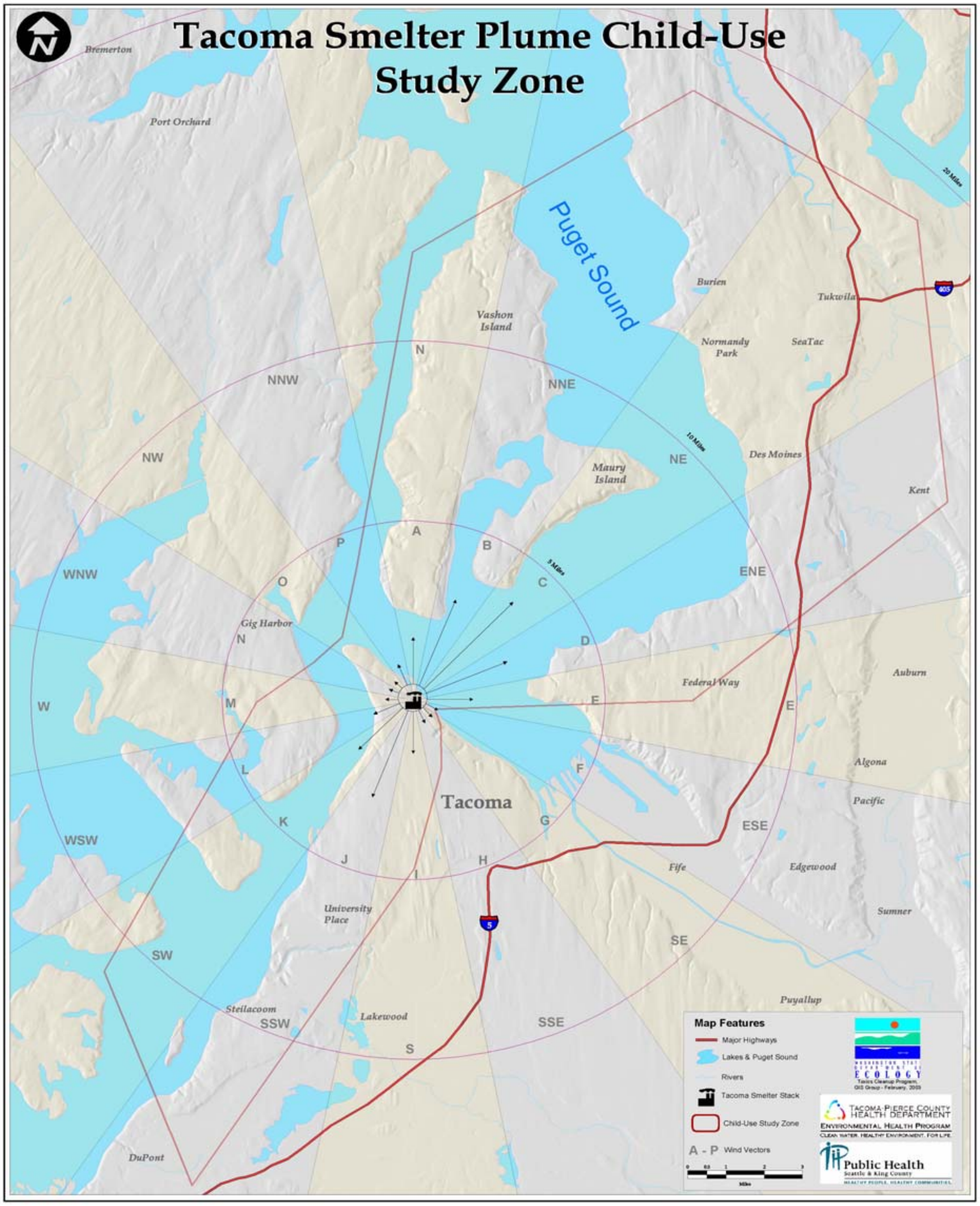


Table 4: Summary statistics for arsenic concentrations by wind vector.

Wind vector	Mean concentration 0-2 in	±SD	Min	Max	Mean concentration 2-6 in	±SD	Min	Max
D	16.36	8.63	8.82	42.10	11.80	5.66	3.09	42.10
E	11.31	8.18	1.08	25.80	12.25	9.36	1.08	32.90
H	4.55	4.74	0.94	17.50	4.90	3.86	0.94	17.50
I	15.01	20.01	0.95	142.00	15.04	16.21	0.95	142.00
J	18.30	39.59	0.96	557.00	20.70	46.04	0.96	691.00
K	3.29	2.87	1.01	8.61	3.02	2.59	1.01	8.92
L	4.83	2.19	2.58	10.30	4.31	1.69	2.46	10.30
M	3.67	0.98	2.05	5.16	3.23	1.03	2.02	5.16

Table 5: Summary statistics for lead concentrations by wind vector.

Wind vector	Mean concentration 0-2 in	±SD	Min	Max	Mean concentration 2-6 in	±SD	Min	Max
D	50.78	82.66	13.80	311.00	21.90	59.54	4.45	311.00
E	25.53	21.52	1.83	77.30	26.65	23.90	1.74	99.70
H	13.93	12.03	1.34	38.50	15.59	13.48	1.32	50.90
I	43.66	58.89	1.67	382.00	40.88	56.78	1.39	382.00
J	41.68	68.20	2.10	807.00	39.53	68.63	1.62	1040.00
K	5.93	5.40	1.39	16.90	5.08	5.36	1.38	19.50
L	9.65	6.46	3.79	24.90	7.20	5.53	2.75	24.90
M	11.47	2.86	2.86	16.00	9.05	3.21	4.52	16.00

An analysis of variance (ANOVA) of arsenic and lead results by depth layer, across each wind vector, showed significant difference between wind vectors (one-way ANOVA: $p=0.001$ for As; $p = 0.000$ for lead). (See attachment G for the statistical comparison). That is - the distribution of arsenic and lead in a depth layer differs across wind vectors. A multiple comparison of the distributions (e.g., Dunnett's) was not performed to determine which vectors are driving the difference. However, the relationships are illustrated graphically in figures 6 and 7. Arsenic and lead values in the 0-2" range in the prevailing wind directions (vectors D, I, and J) were higher than the results for the 0-2" range in the other vectors; the same holds true for the 2-6" range except for vector E. It should be noted that the sample sizes for wind vectors D, E, L, and M were fairly small (24 samples in vectors D and M, and 32 samples in vectors E and L).

Pairwise comparisons (t-tests) of arsenic and lead results between 0-2" layer to the 2-6" layer <u>within</u> each wind vector were not performed to evaluate significant differences between depth layers in each wind sector. However, this relationship can also be seen graphically in Figures 6 and 7. In vectors D, K, L, and M, arsenic levels appear to be higher in the 0-2" layer than the 2-6" layer, while the opposite is the case in vectors E, H, I, and J. Except for vectors E and H, lead levels appear to be higher in the 0-2" layer than the 2-6" layer. Reminder: with the high variability of the data set, these differences are not significant.

4.3.3 Arsenic/Lead correlation

Data from the Pierce County Footprint Study show evidence of a roughly 2:1 ratio of lead to arsenic. Regression analyses were performed for the CUA data to statistically evaluate the relationship between arsenic and lead. A series of scatterplots was prepared which graphed the $\log_{10}$ ratio of arsenic to lead for both depths combined in the different wind vectors (Attachment F). A $\log_{10}$-$\log_{10}$ plot of the data produced a nominal linear relationship. Wind vectors E and L show fairly high correlation between arsenic and lead: E ($R^2 = 0.9142$) and L ($R^2 = 0.9179$). The lead to arsenic ratio for these vectors is: E = 1.2:1, and L = 1.03:1; lower than what is seen in the Footprint Study. This probably reflects a high level of soil disturbance, and is certainly influenced by the high degree of variability.

Table 6: Linear Regression Analysis Results

Data Set (both depths combined)	Sample Size (n)	R^2
Vector D	24	76.4%
Vector E	32	91.4%
Vector H	40	86.8%
Vector I	283	69.6%
Vector J	723	78.0%
Vector K	48	72.4%
Vector L	32	91.8%
Vector M	24	39.5%

Figure 4. Arsenic distribution by wind vector

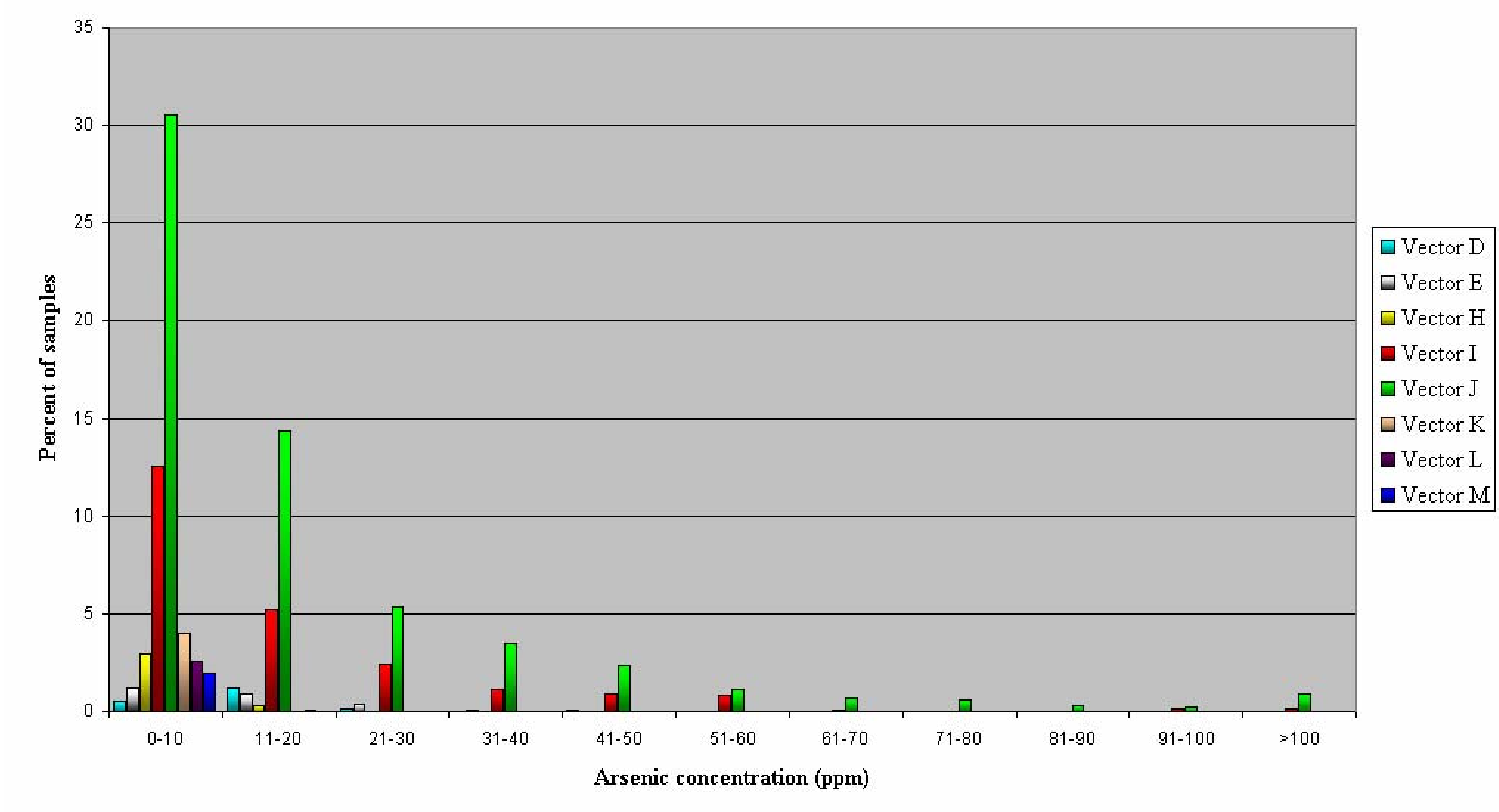


Figure 5. Lead distribution by wind vector

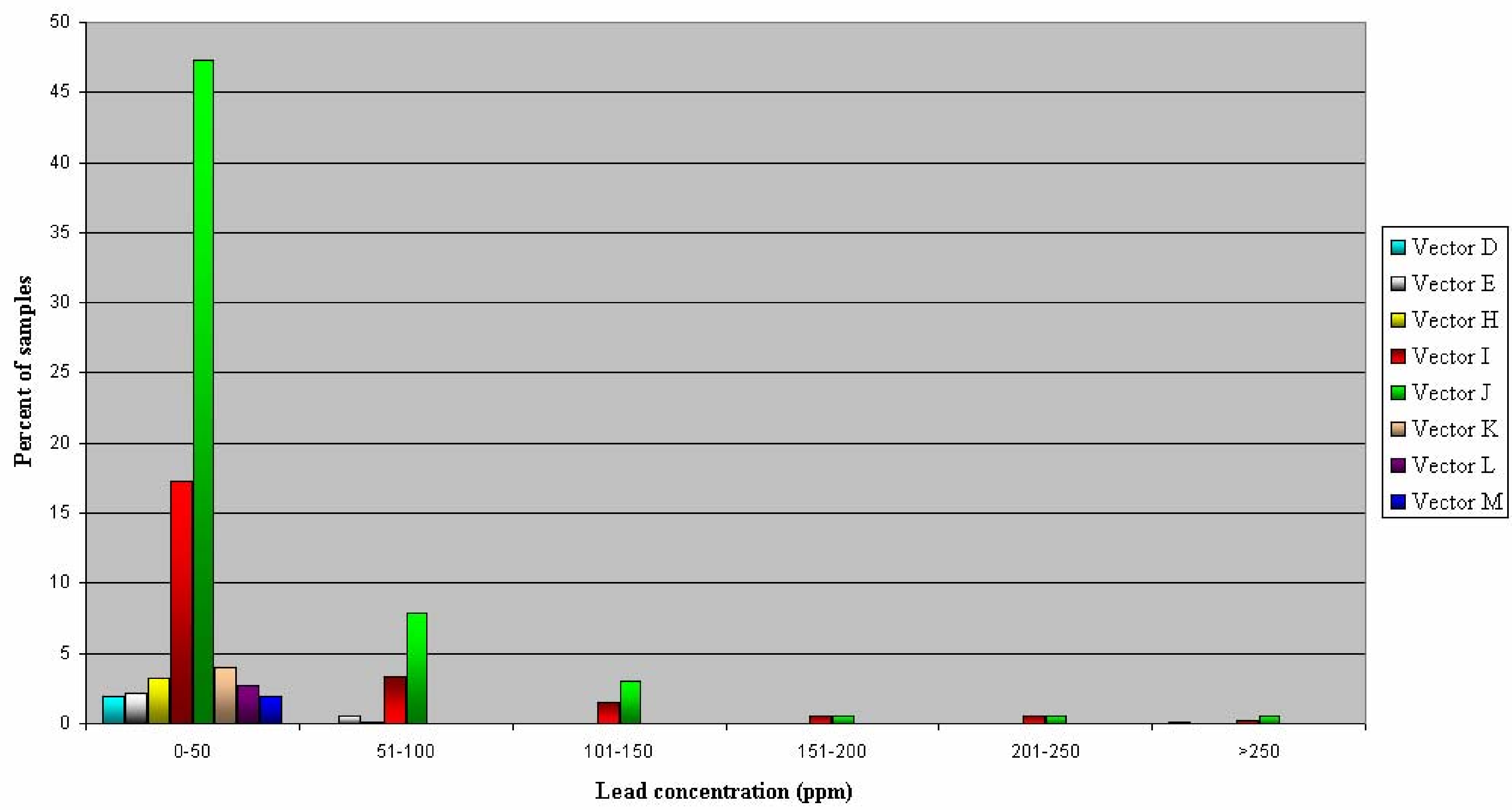


Figure 6. Mean arsenic concentration by wind vector and depth

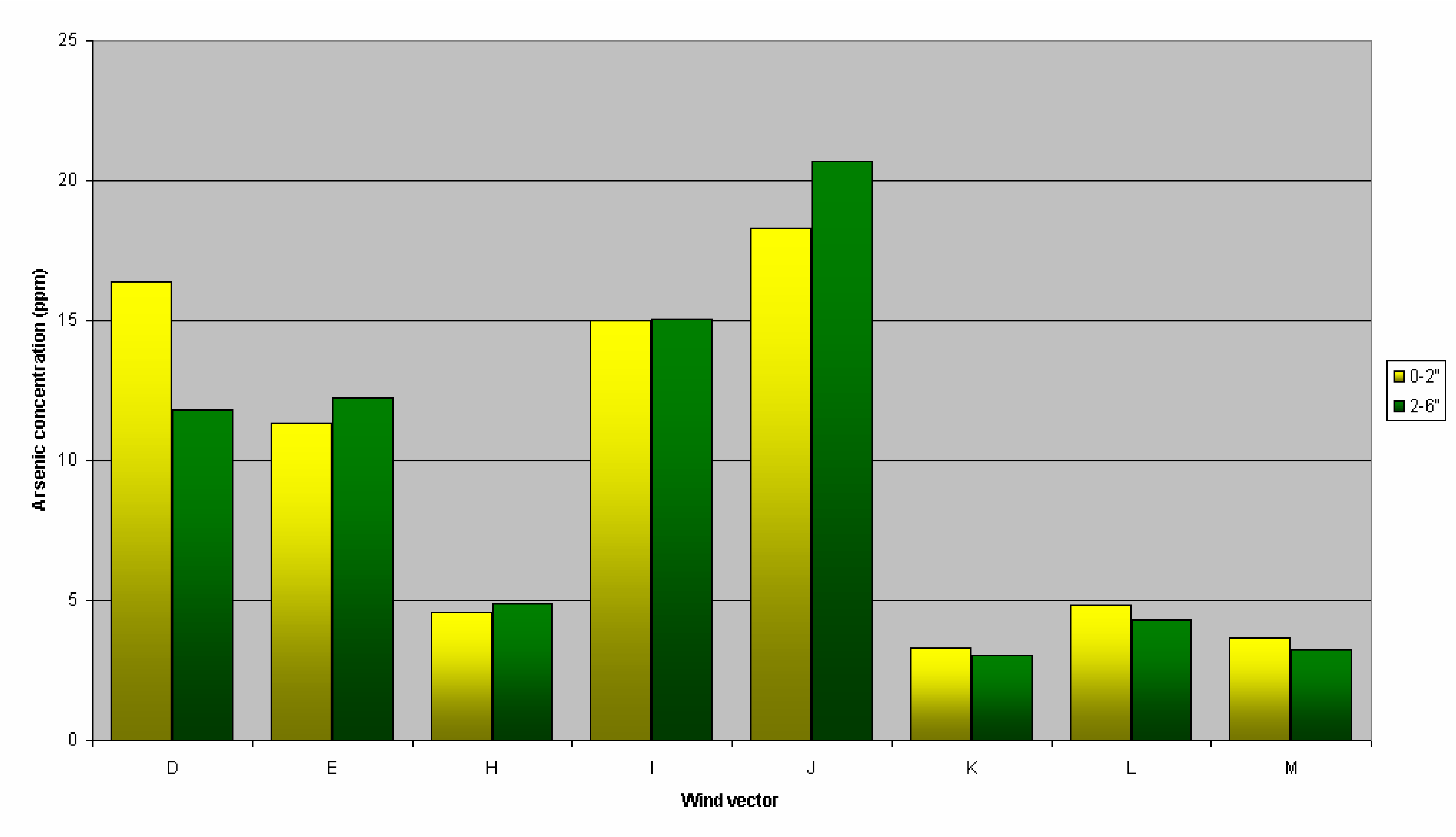
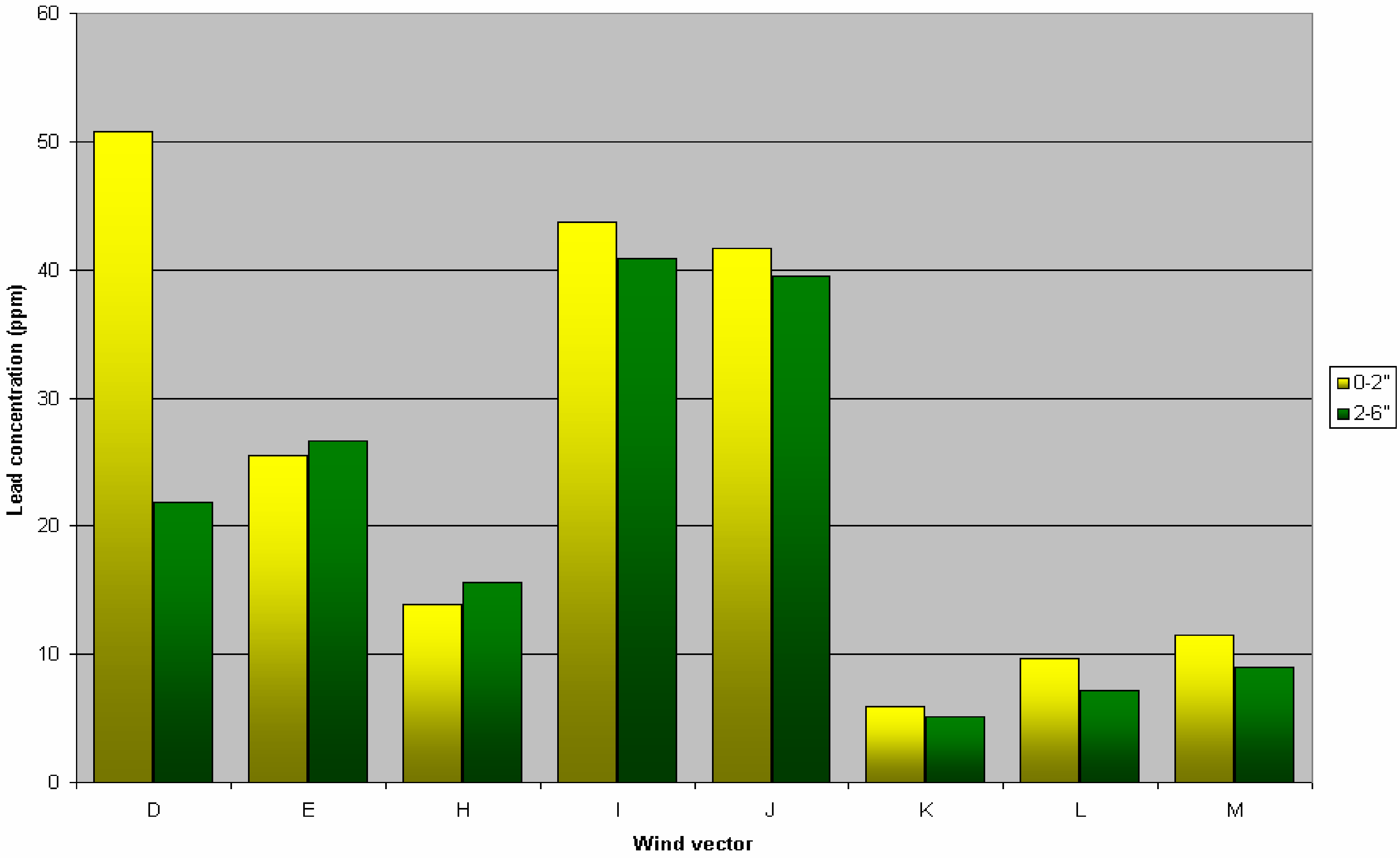


Figure 7. Mean lead concentration by wind vector and depth



5 CONCLUSIONS AND RECOMMENDATIONS

The lack of any clear pattern between wind vectors, and between depths reflects the high variability of the data likely due to the level of disturbance of the soil over time. Unlike the Pierce County Footprint Study, which attempted to sample the most undisturbed properties across an evenly-spaced grid, the CUA study included a random sampling of often highly disturbed properties, making statistical analysis of the data difficult.

What is clear from this study is that many Pierce County child use areas have elevated soil concentrations of lead and arsenic. Arsenic in soils at two properties exceeded the Interim Action Trigger Levels. At Pt. Defiance Elementary, the Tacoma School District voluntarily undertook cleanup of part of the property, replacing contaminated soil from a baseball field with clean fill, and covering part of the play area with asphalt. At child care #112, the child care opted to keep children from playing on the contaminated soils (this child care did not provide an outdoor play area anyway).

Within the Child Use Area study zone, access was granted to sample 19 of 24 elementary schools, 21 of of 40 parks, and only 32 of 130 child care facilities. Uncertainties about funding and requirements for cleanup were a major concern for Metro Parks and for private child care operators and prevented access being gained for sampling at many sites. Other facilities within the study zone may also contain elevated levels of arsenic and lead.

This study intended to serve short-term health screening needs. Ecology has published a *Dirt Alert - Arsenic and Lead in Soils* brochure (Ecology 2003) that offers property owners practical information about the Tacoma Smelter Plume project and assistance on what to do if the owner wants to know more about contamination on their property. These brochures were given to property owners at the time of sampling, and additional materials mailed out along with the results. TPCHD has also published information about how to minimize an individual's exposure to arsenic and lead in soils, listed below. Inside the home:

- Take off shoes before entering your home.
- Wash hands and face thoroughly after working or playing in the soil, especially before eating.
- Damp mop and wipe surfaces often to control dust.
- Wash toddler toys and pacifiers often.
- Scrub vegetables and fruits with soap and water.
- Wash clothes dirtied by contaminated soil separately from other clothes.
- Repair painted surfaces in homes. Homes built before 1980 may contain lead-based paint. Older paint flakes may be a source of lead.
- Eat a balanced diet. Iron and calcium help keep lead from becoming a problem in the body.
- Use water and soap to wash – avoid "waterless" soaps.

Outside the home:

- Keep children from playing in contaminated dirt.
- Cover bare patches of dirt with bark, sod or other material, or fence off area.
- Dampen dusty soils before gardening.
- Wear gardening gloves.
- Do not eat or drink in contaminated areas.
- Keep vegetable gardens away from old painted structures and treated wood.
- Do not plant food crops under the roof overhang of homes.
- Keep pets off of exposed dirt so they don't track it into the house.

Special considerations for adults doing construction or yard work:

- Avoid all unnecessary exposure to soil or dust.
- Dampen dusty soils before and during the work project.
- Wear full body protective clothing (coveralls, or long sleeve shirt and pants,) shoes, and gloves. For maximum protection wear a dust mask or respiratory protection.
- Avoid eating, drinking or smoking while working in dirt.

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